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Efficient Adaptive Algorithms for an Electromagnetic Coefficient Inverse Problem

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ABSTRACT

This thesis comprises five scientific papers, all of which are focusing on the inverse problem of reconstructing a dielectric permittivity which may vary in space inside a given domain. The data for the reconstruction consist of time-domain observations of the electric field, resulting from a single incident wave, on a part of the boundary of the domain under consideration. The medium is assumed to be isotropic, non-magnetic, and non-conductive. We model the permittivity as a continuous function, and identify distinct objects by means of iso-surfaces at threshold values of the permittivity.

Our reconstruction method is centred around the minimization of a Tikhonov functional, well known from the theory of ill-posed problems, where the minimization is performed in a Lagrangian framework inspired by optimal control theory for partial differential equations. Initial approximations for the regularization and minimization are obtained either by a so-called approximately globally convergent method, or by a (simpler but less rigorous) homogeneous background guess.

The functions involved in the minimization are approximated with finite elements, or with a domain decomposition method with finite elements and finite differences. The computational meshes are refined adaptively with regard to the accuracy of the reconstructed permittivity, by means of an a posteriori error estimate derived in detail in the fourth paper.

The method is tested with success on simulated as well as laboratory measured data.

Keywords: coefficient inverse problem, inverse scattering, Maxwell's equations, approximate global convergence, finite element method, adaptivity, a posteriori error analysis